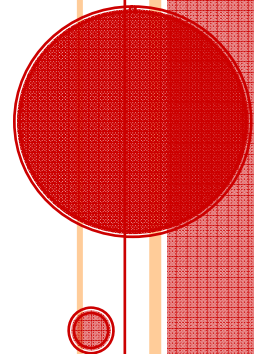


# A CLINICAL PERSPECTIVE OF DIGITAL MAMMOGRAPHY

*Evaluating Choices in  
Mammography Displays*

*By Mary Beth Massat*



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## *Evaluating Choices in Mammography Displays*

### **Introduction**

Full-field digital mammography (FFDM) has long been called the “last digital frontier” in radiology. While many radiographs became digital long before mammography, adoption rates have skyrocketed in the U.S. since the release of the American College of Radiology Imaging Network - Digital Mammographic Imaging Screening Trial (ACRIN-DMIST) results in September 2005. The ACRIN-DMIST trial compared digital to film-based mammography and included multiple institutions and approximately 49,500 women.

In the month preceding the announcement of the ACRIN-DMIST results, 680 U.S. Food and Drug Administration (FDA) Mammography Quality Standards Act (MQSA) accredited facilities had FFDM; three years later (November 2008) that number jumped to 3,896, or 44 percent of all accredited facilities.<sup>1</sup>

Why do facilities convert to digital mammography? The true value of digital mammography is the improved image resolution, says Stamatia V. Destounis, MD, Elizabeth Wende Breast Care, LLC. “We can see things that we’ve never seen before on film, such as more subtle masses, microcalcifications and spiculations.”

Raymond Friedman, MD, Oregon Health Sciences University (OHSU) agrees, “With the digital image, I can see the skin, nipple and thru dense glands. We would have to make the film very light or black to see these same features.”

Martin J. Yaffe, PhD, Tory Chair in Cancer Research and Senior Scientist Imaging Research Program at Sunnybrook Health Sciences Centre (Toronto, ON, Canada) and Professor, Departments of Medical Imaging and Medical Biophysics at The University of Toronto, points out another motivation for migrating to digital mammography. ACRIN-DMIST also demonstrated that FFDM provides more accurate results in certain groups of women, namely, those under 50, women at any age with very dense or extremely dense breasts, or those who are pre- or perimenopausal.<sup>2</sup>

Yet, talk to any radiologist and they will tell you digital mammography slows down even the most experienced film-based mammographers. For 30 years, Dr. Friedman has read screening mammograms, typically spending one to two minutes on each study. Today at OHSU, he spends between 10 to 15 minutes reading and reporting each digital mammogram. “More microcalcifications are seen, often of unknown significance. It is truly a brand new learning curve reading digital mammograms,” he says.

Dr. Destounis agrees that a key limiting factor of digital mammography is the learning curve, specifically the image evaluation process, such as magnifying, panning and zooming the images, and adapting to multiple hanging protocols for both screening and diagnostic patients. Yet, while the radiologist slows down, the tech is able to speed up with digital mammography. Because of this, Dr. Destounis says, one FFDM can replace two to three film-based units; increasing the technologists’ productivity can positively impact patient throughput, which may help many facilities absorb the higher upfront capital costs of digital mammography versus film-screen mammography.

Clearly, there are image quality advantages and workflow challenges that result from implementing FFDM. The choices made in selecting a mammography acquisition unit, image processing algorithm and mammography display all play a role in determining image quality and the impact on radiology workflow. The purpose of this article is to highlight key purchasing considerations for mammography displays.

Prior to 2004, digital mammograms were most often viewed on CRT monitors. However, advancements in LCD technology have brought this technology to the forefront in radiology. In particular, response times, viewing angles, input lag and black contrast ratios have improved significantly over the past five years. In fact, in the fourth quarter of 2007, commercial LCDs surpassed CRTs in worldwide sales.<sup>3</sup>

Today, LCDs designed specifically for medical image viewing are the display of choice for radiologists. LCD technology must support the key advantages of digital mammography, namely image quality and radiology workflow.

Mammography facilities have a choice in the selection of a digital mammography display, therefore, it is important that users understand that not all LCD mammography displays are created equal. What makes one display better for viewing mammography images versus another? There are several factors to consider, specifically, productivity and the impact on workflow, functionality and accuracy of the displayed image, and quality assurance and control.

## Productivity and Workflow

One of the most important factors when implementing digital mammography is for mammographers to efficiently adapt to this new workflow without missing critical findings. One aspect of efficiency as it relates to the mammography workstation is how fast the images load. With many digital mammography studies averaging 150 MB and approaching 200 MB, loading images quickly is critical. Add the need to pull digitized priors, and the power of the display's graphic card becomes more important in mammography workflow.

The display controller and available memory also impact the time it takes to load studies. Display systems that load current and prior studies in less than a second, or near instantaneous, can lead to more efficient screening.

Yet, productivity and workflow are dependent upon more than just the speed and power of the display controller. Productivity tools such as magnification, zooming and panning help mammographers adapt to this new workflow and impact reading efficiency.

Magnification tools and reversing the image from black-to-white and white-to-black are common tasks for virtually any mammographer. In the OHSU reading room, Dr. Friedman can easily magnify and reverse the image from black-to-white and white-to-black on the Coronis 5MP Mammo (Barco, Kortrijk, Belgium). Fast roaming and smooth image manipulation enhance productivity. "You want to zoom freely and not be limited by the speed at which you can enlarge the image," he adds.

The ability to magnify through the entire spectrum of images may also be of benefit, notes Dr. Friedman. Other frequently used functions are image panning and measurements, both necessary tools for evaluating changing breast anatomy. Plus, the ability to display mammography CAD markings, apply new annotations on the displayed image and save is critical. As such, each of these tools should be readily accessible and easy to use on the display.

The bottom line, says Pat Montgomery, Manager, Women's Care at AGFA, is to "make sure that the diagnostic review workstation has an efficient workflow for the radiologist. Utilizing a review station that is FDA cleared for digital mammography doesn't necessarily ensure an efficient workflow."

## Functionality and Accuracy of the Image

Contrast and resolution are two of the most important technical features of mammography displays that help the mammographer detect subtle changes in shading and small anatomic details without the use of excessive magnification. Display resolution relates to the number of pixels and the actual spatial extent of each pixel.

The ACR Practice Guidelines also recommend a minimum of 8-bit output luminance resolution.<sup>4</sup> However, Siegel et al recommend 9 or 10-bit depth resolution for higher luminance ratios and note that this is particularly important in mammography due to the appearance of subtle grayscale changes in the breast soft tissue.<sup>5</sup>

Contrast ratios refer to the ratio of the luminance of the brightest (white) to the darkest (black) color. Following AAPM TG 18 guidelines, the contrast response should fall within 10% of the DICOM Grayscale Standard Display Function (GSDF) contrast values to ensure that pixel values appear true to the human eye. DICOM GSDF improves conspicuity of findings in extreme luminance conditions and provides a method to standardize image appearance on displays.<sup>6</sup>

According to Dr. Friedman, it is important to evaluate the monitor to determine if it has the right black and white contrast ratio so the screen is not so bright that there is glare, and not so black that it hides inconspicuous lesions.

Montgomery agrees that contrast plays a key role in optimizing the best viewing quality for mammography. “There is a wide span of contrast levels and since quality of the image is paramount, start here,” she recommends. The highest contrast that Montgomery has found with LCDs is 900:1.

In addition to contrast ratios, pixel size and center-to-corner luminance uniformity are critical issues when viewing objects that may be smaller than a pixel. The ACR Practice Guidelines recommend an “ideal maximum luminance of 450 cd/m<sup>2</sup> or higher to avoid too low a value for minimum luminance, which is susceptible to ambient lighting.”<sup>4</sup> Within the display’s luminance range, the display should render image details with a consistent grayscale, measured and maintained over time.

Image rendition is important since a mammographer judges and interprets the size of features visually. The ACR guidelines specify that displayed images are true to size and that images from different acquisition stations, with different pixel sizes, display at the “same size.” A ruler on the display

screen is a useful visual clue to physical size. Deviations from displaying “same size” mammograms can lead to additional image manipulation and interpretation time.

Montgomery also recommends looking at the backlight warranty to evaluate the lifespan of the medical display. Some monitors offer a 5- to 10-year lifespan while others are only one to two years, she notes.

Pixel uniformity is another important consideration that impacts the accuracy and integrity of the image, which can also influence the presence of noise. While all LCDs introduce some degree of noise in the displayed image as a result of luminance fluctuations, this effect can be minimized with pixel uniformity technology. If the luminance output of each pixel varies, then small, subtle details that the human eye can perceive may also be missed. Pixel uniformity technology can measure and adjust the luminance output at the pixel level, eliminating screen noise and making each individual pixel DICOM-compliant. Conformance to the center-to-corner luminance uniformity, as specified in DIN 6868-57, also helps eliminate screen noise.

## **Quality Assurance and Control**

The ACR guidelines for softcopy mammographic displays recommend regular calibration to maintain compliance. Consistent and accurate representation of the image across displays and throughout the product lifetime are critical to ensuring diagnostic confidence and accuracy.

Radiologists should understand the limitations of some LCDs, says Yaffe. He points out that while the resolution of flat panel monitors does not change over time, the brightness often does. Ask the manufacturer what level of brightness is guaranteed. Regular calibration of the monitors ensures optimal image contrast, as well as matching of brightness in a multi-monitor environment, adds Yaffe. He also recommends that viewing rooms are designed to minimize the effects of ambient light reflection.

Many monitors degrade throughout the product lifetime. Therefore, it is very important to maintain the consistency of the image daily, weekly, or monthly, particularly to determine if there are any dead pixels. End users can inquire if the system is properly calibrated and how, what is its expected lifespan, and what is covered by the warranty.

Pixel size impacts spatial resolution. Following the AAPM TG 18-CX test patterns, each image pixel should map to one display pixel (or one to one pixel mapping). Pixel pitch also affects the image sharpness: the smaller the

pitch, the fewer granularities are present in the image. This is why 5 megapixels is the standard resolution for digital mammography.

With LCD monitors, viewing angle affects monitor brightness. According to Yaffe, two radiologists standing at different positions in front of the LCD may not see the same thing, because of variations across the viewing angle. He also cautions against decreasing contrast performance when light from other light sources, such as a conventional film box, falls on the surface of the LCD.

## **Conformance to Industry Standards**

Correct, accurate display of the mammogram is critical to achieving the right diagnosis. Mammographers should have the capability to scale images from different FFDM acquisition units for comparison of priors with current studies. Combining these various studies on one workstation is a challenge.

The FDA has issued an advisory, stating that when images from some FFDM units are displayed on some third-party PACS, the image identification information may obscure breast tissue on hard copy images.<sup>7</sup>

The concern is that a radiologist could overlook or incorrectly characterize a lesion, particularly in the obscured breast tissue. In addition to following the FDA's recommendation that all facilities verify that image-identifying information is correctly displayed, facilities should ensure that vendors comply with both the DICOM standard and the Integrating the Healthcare Enterprise (IHE) Mammography Image Profile.

Workstations should support DICOM query and retrieve of digital mammograms from DICOM archives as well as support receipt of DICOM-compatible mammography images and CAD structured reports "for presentation."

For any image display that supports the IHE Mammography Image Profile, it "shall support calibration as described in the DICOM Grayscale Standard Display Function (GSDF)."<sup>8</sup> While the minimum and maximum luminance of the display can be configurable by site, it must conform to local, regional or national regulations.

## Summary

As with other diagnostic imaging modalities, mammography is going digital. For hospitals, clinics and physician offices, the question is not if they implement FFDM, rather when. “The switch to digital doesn’t happen overnight,” Dr. Destounis says. She recommends migrating from film-screen to digital mammography in steps so that the staff can be sufficiently re-trained. This includes replacing one unit at a time, particularly since a facility may not need to replace mammography units on a one-to-one ratio.

Careful consideration of all FFDM components – from the acquisition device to the display – and the impact on productivity, workflow and image quality will help determine the level of success. While defining success will vary among healthcare institutions, it can be defined by increasing patient throughput, detecting lesions earlier, and reducing patient call-backs, particularly among women whose studies are negative after additional mammographic imaging.

Both Dr. Friedman and Dr. Destounis note that their facilities initially call back more patients than before. However, Dr. Destounis does believe that this is a temporary condition that results from the mammographer’s ability to see things they didn’t see on film. “It can take months to years to become accustomed to reading mammograms on a display,” she adds, depending on the facility volume.

Careful evaluation of available mammography displays is just as important as assessing the acquisition device. No two mammography displays are identical, and therefore, users should examine the impact on productivity and workflow, functionality and accuracy of the image rendering, and quality assurance and control.

References:

1. MQSA Facility Scorecard. Available at: <http://www.fda.gov/cdrh/mammography/scorecard-statistics.html>
2. Pisano E, Gatsonis C, Hendrick E, Yaffe M, Baum J, Acharyya S, et al. Diagnostic Performance of Digital versus Film Mammography for Breast Cancer Screening - The Results of the American College of Radiology Imaging Network (ACRIN) Digital Mammographic Imaging Screening Trial (DMIST). *NEJM*, published online September 16, 2005 and in print on October 27, 2005.
3. Murph, D. Worldwide LCD TV shipments surpass CRTs for first time ever. *engadgetHD* Feb. 19, 2008. Available at: <http://www.engadgethd.com/2008/02/19/worldwide-lcd-tv-shipments-surpass-crts-for-first-time-ever/>
4. Practice Guidelines for Determinants of Image Quality in Digital Mammography. ACR Practice Guideline 2007 (Res. 35); pgs 500-504. Available at:
5. [http://www.acr.org/SecondaryMainMenuCategories/quality\\_safety/guidelines/breast/image\\_quality\\_digital\\_mammo.aspx](http://www.acr.org/SecondaryMainMenuCategories/quality_safety/guidelines/breast/image_quality_digital_mammo.aspx).
6. Seigel E, Krupinski E, Samei E, Flynn M, Andriole K, Erickson B, et al. Digital Mammography Image Quality: Image Display. *J Am Coll Radiol* 2006;3:615-627.
7. IE-5 (see article for reference)  
[http://www.imagingeconomics.com/issues/articles/2002-12\\_08.asp?mode=print](http://www.imagingeconomics.com/issues/articles/2002-12_08.asp?mode=print)
8. Health Imaging & IT News. Available at: <http://www.healthimaging.com/content/view/11678/89/>
9. IHE Mammo Profile. Available at: <http://www.ihe.net/Mammo/>

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Mary Beth Massat is President of Massat Media, LLC, a healthcare marketing communications consulting and freelance writing firm based in Crystal Lake, IL.

Prior to forming Massat Media, Mary Beth was editorial director at Reilly Communications Group, publisher of Imaging Technology News, Diagnostic & Invasive Cardiology, Acuity Care Technology and Outpatient Care Technology. Mary Beth's career spans over 16 years of healthcare-specific writing, editing and marketing communications. Her areas of expertise include radiology and cardiology diagnostic imaging modalities and informatics solutions.

Mary Beth has authored numerous articles on technology and trends in the radiology and cardiology healthcare segments. She co-authored a chapter on biometrics in the technology primer, "Security Issues in the Digital Medical Enterprise," published by the Society for Imaging Informatics in Medicine (SIIM), and was a member of the guest faculty at the DHIMS 2008 conference (formerly PACS), presenting one session on marketing imaging solutions and a second on the ROI of imaging solution.

